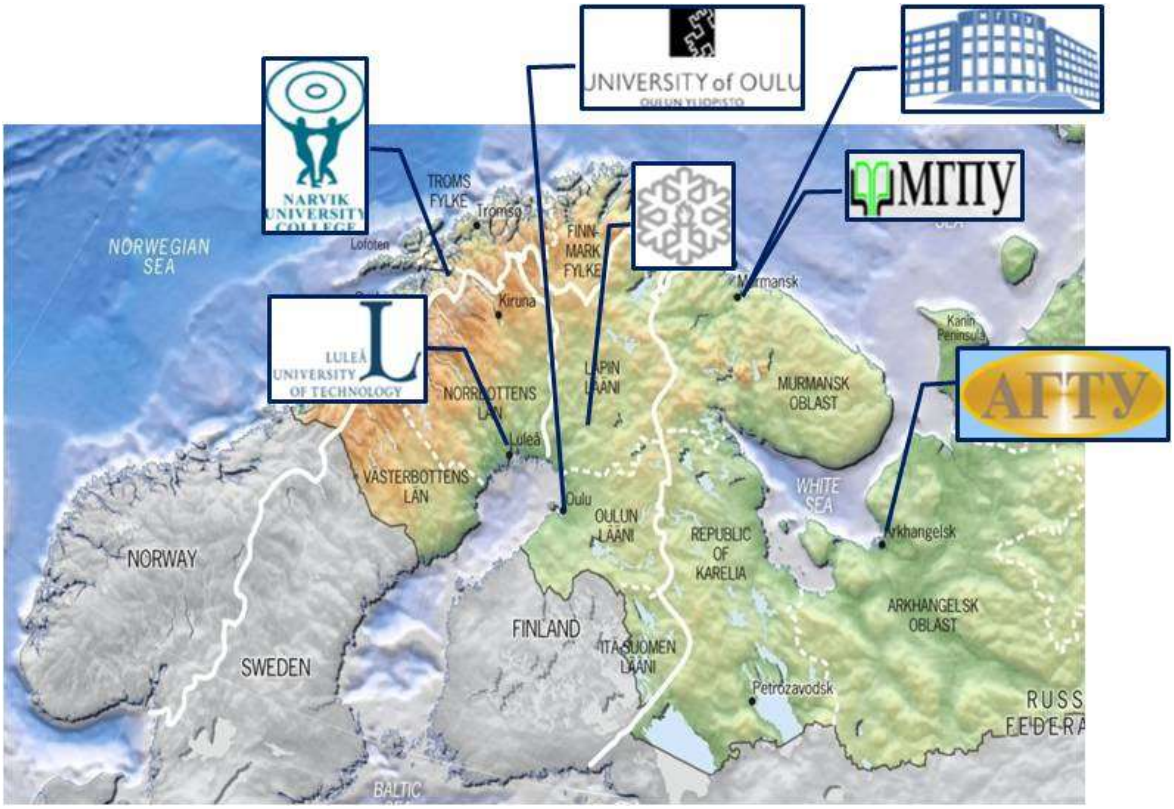
Barents Cross Border University

**Barents Master's Programme**
**in Environmental Engineering**

# STUDY GUIDE 2010 – 2012




Map: Hugo Ahlenius, UNEP/GRID-Arendal *http://maps.grida.no/go/graphic/barents_region_topography_and_bathymetry3*
2009

BEE Study guide 2010-2012
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Thule Institute & Department of Process and Environmental Engineering
University of Oulu, August 2010

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Barents Cross Border University
**Barents Master's Programme**
**in Environmental Engineering**

# Study Guide 2010 - 2012

**University of Oulu, Finland**
Narvik University College, Norway
Northern (Arctic) Federal University, Russia
Murmansk State Technical University, Russia
Luleå Technical University, Sweden
Pomor State University, Russia

## CONTENTS

# 1 INTRODUCTION TO THE BARENTS CROSS BORDER UNIVERSITY

The Barents Cross Border University, BCBU, is a project aiming to develop and jointly organise international, multidisciplinary Master's programmes. The programmes follow the principles of the Bologna process and the teaching is given in English in all. Later the cooperation will also cover doctoral education in the same fields. The project is based on the co-operation between universities in Northern Finland and Scandinavia and Northwest Russia. This co-operation was founded on 2006 (intention agreement undersigned on March 2007) in the mutual interests of the partner universities, as well as in the principles and aims of the partnership programmes and the EU Northern Dimension Policy[1].

Within the BCBU, there are two partner universities in Finland, eight from Russia, and five partners from other countries. The partners from Finland are the University of Oulu and the University of Lapland in Rovaniemi. From Russia, the partners are Northern (Arctic) Federal University, Pomor State University, and Northern State Medical University in Arkhangelsk, Petrozavodsk State University and the Karelian State Pedagogical University in Petrozavodsk, and Murmansk State Technical University, Murmansk State Pedagogical University, and Murmansk Humanities Institute in Murmansk. The BCBU associate partners are Narvik University College in Norway, Luleå University of Technology in Sweden, the University of the Southern Denmark in Denmark, the Centre for Health Education in Greenland, and University of Manitoba in Canada.

The BCBU partners collaborate together to provide four two-year cross border Master's degree programmes, on the fields of social work, environmental engineering, information and communication technology, and circumpolar health and well-being. *Master's Programme on Comparative Social Work* is coordinated by the University of Lapland, and *Barents Environmental Engineering, Information Systems*, and *Health and Wellbeing in Circumpolar Areas* are coordinated by the University of Oulu. The combination of the partner universities in each programme is based on the former cooperation and the expertise in special branches of the participating universities. The study programmes are in the central fields of the EU Northern Dimensions priorities and the language of study in all programmes is English.

BCBU offers graduates increased professional and international skills necessary to improve the personal lives and to scale up professional possibilities of the graduates. The needs of international labour market, both in the Barents region and globally, are used as the basis for these studies. In addition, these BCBU Master's programmes are intended to promote the internationalisation of education and research, by updating educational contents and by incorporating international aspects in the educational processes.

Further information about Barents Cross Border University project is available at the BCBU home page http://bcbu.oulu.fi, and about the respective Master's programmes at:

- Comparative Social Work http://www.ulapland.fi/CSW
- Barents Environmental Engineering[2] http://bee.oulu.fi
- Information Systems http://gs3d.oulu.fi/
- Circumpolar Health and Well-being http://arctichealth.oulu.fi/suomi/maisterikoulu.html

[1] EU Northern Dimension Policy, see: http://ec.europa.eu/external_relations/north_dim/index_en.htm

[2] Officially 'Master's Degree Programme (BCBU) in Environmental Engineering', see http://www.finlex.fi/fi/laki/alkup/2009/20091665

# 2 MASTER'S DEGREE PROGRAMME IN ENVIRONMENTAL ENGINEERING

The Barents Environmental Engineering (BEE) Master's Degree Programme, officially called *Master's Degree Programme (BCBU) in Environmental Engineering*, is a two-year programme of 120 ECTS, including an exchange period in one of the participating universities in Norway, Sweden or Russia. Graduating students will be awarded a degree of Master of Science in Engineering from the University where they are accepted and registered, a diploma supplement from the university where exchange period has been taken, and also a BCBU certificate.

The BEE programme is based on environmental, process, and civil engineering. The curriculum is multidisciplinary, including subjects ranging from these engineering sciences to ethics and legislation, economics and ecology. The programme was developed and is carried out in international cooperation with the participant universities: University of Oulu and University of Lapland in Finland, Narvik University College in Norway, Luleå Technical University in Sweden, and Northern (Arctic) Federal University, Pomor State University and Murmansk State Technical University in Russia.

## 2.1 General information on the main BEE partner universities

### 2.1.1 University of Oulu

The University of Oulu (UO), Finland, is an international multidisciplinary research university, and one of the largest universities in Finland with an exceptionally wide academic base. Six faculties (Humanities, Education, Economics and Business Administration, Medicine, Science, and Technology) and their departments form a multidisciplinary academic community that enables diversified studies based on multifaceted research. The fields of information technology, bio-technology, and northern and environmental issues have been defined as the special research focus areas. UO cooperates closely with industry and commerce, and has broad connections with hundreds of international research and educational institutions. The university also provides a high-quality learning environment for both specialists and generalists in its 50 different degree programmes.

By applying a multi-disciplinary approach, the focus area of northern and environmental issues explores how climate and environmental changes are impacting northern areas. The ultimate aim is to find new, sustainable ways of protecting and using the northern environment and its natural resources. Other interests include studying the health, welfare and culture of the people living in the area. The University of Oulu has a leading role in the Thule Institute Global Change in the North Research Programme[3] and in the Northern Research Platform of the European Research Area. In UO, the Department of Process and Environmental Engineering together with the Thule Institute, is the responsible organiser of the BEE programme studies. University of Oulu main webpage, see www.oulu.fi/english/.

### 2.1.2 Narvik University College

The Narvik University College (NUC), Norway, is one of 26 State University Colleges in Norway which offer higher education through various study programmes. The number of students attending NUC is about 1200, spread out on a number of undergraduate, graduate and postgraduate study programmes in the fields of engineering, health and nursing, and business management. NUC is organised in four departments: Department of Building, Production and

[3] Global Change in the North Research Programme, see: http://thule.oulu.fi/englanti/research/change.html

Engineering Design; Department of Scientific Computing, Electrical Engineering and Space Technology; Department of Applied Sciences; and Department of Health and Nursing Science. Department of Building, Production and Engineering Design focuses on e.g. renewable energy, energy in buildings, and energy efficiency. Narvik University College is participating in the education of the Barents Environmental Engineering Master's Programme (BEE), especially in the area of sustainable energy. Narvik University College's main webpage, see www.hin.no/eng.

### 2.1.3 Luleå University of Technology

The Luleå University of Technology (LTU), Sweden, is the northernmost university of technology in the Scandinavia and conducts research in the Faculty of Engineering and in the Faculty of Arts and Social Sciences. Research at LTU comprises 70 research subjects in 13 departments and is characterised by multidisciplinary cooperation between the University's research departments and close interaction with trade and industry and society. LTU will participate in education of the BEE programme. Luleå University of Technology's main webpage can be found at http://www.ltu.se/english.

### 2.1.4 Northern (Arctic) Federal University

The Northern (Arctic) Federal University (NArFU) , Russia (former Arkhangelsk State Technical University, ASTU) has active cooperation with authorities, industrial companies, scientific-research, educational and cultural institutions in the Arkhangelsk region. It has over 3 000 employees, and nearly 14 000 students, of which more than 7500 are full-time. NArFU provides approximately 50 five-year degree programmes for main industrial branches of the region. It has cooperation agreements with 25 universities from 10 foreign countries. NArFU will participate in education of the BEE programme. Northern (Arctic) Federal University's main webpage, see http://www.agtu.ru/english_1.

### 2.1.5 Murmansk State Technical University

Murmansk State Technical University (MSTU), Russia, has nine faculties and more than 30 departments that train specialists in 28 fields. The main purpose of the University is providing all the branches of industry with well-qualified specialists. It has approximately 4500 students and nearly 400 employees. Its Natural and Technical Faculty has long trained experts on ecology and environmental management. MSTU actively develops international cooperation, in particular in implementing joint Russian–Finnish educational projects in environmental engineering. MSTU will participate in the education of the BEE programme. Murmansk State Technical University's main webpage, see http://eng.mstu.edu.ru.

### 2.1.6 Pomor State University

Pomor State University named after M. V. Lomonosov (PSU), Russia, is a research-oriented educational scientific and innovative university with the whole cycle of education. PSU has 21 faculties, 66 departments, and 27 scientific centres and laboratories hosting over 14 000 students and more than 1500 academic staff. The main fields of expertise of PSU are mathematics, regional studies, economics, comparative law, social work, history, and biology. Pomor State University will participate in the education of the BEE programme. Pomor State University's main webpage, see http://www.pomorsu.ru/eng/.

## 2.2 Orientations in the Barents Environmental Engineering Master's Programme

The Barents Environmental Engineering Master's Programme (BEE)[4] is based on environmental, process, and civil engineering. The BEE curriculum is multidisciplinary, including subjects ranging from the before-mentioned engineering sciences to ethics and legislation, economics and ecology. The programme was developed and is implemented by international co-operation. Currently the main responsibility for the delivery of the BEE programme is carried out by the Department of Process and Environmental Engineering at the Faculty of Technology, University of Oulu with three on-going orientations, and also in the two Russian universities there are ongoing orientations related the BEE programme. The programme takes two years with 120 ECTS of studies, including an exchange period in one of the participating universities in Russia, Norway or Sweden.

The graduating students will be awarded degree qualifications by the university where they have been originally accepted and registered. In 2010, graduating students have been be accepted to the University of Oulu, The Northern (Arctic) Federal University (NArFU) (Russia) and Murmansk State Technical University (Russia). The degree qualification of the BEE programme will be a Master of Science in Engineering in all occasions.

Currently the programme includes three ongoing orientations in the one of the BEE partner universities (University of Oulu; Clean Production, Water and Environment, and Sustainable Energy) and also two orientations in the other partner universities in Russia (Integrated Use of Water Resources; and Industrial Ecology and Rational Use of Natural Resources).

### 2.2.1 Clean Production

The Clean Production (CP) orientation includes studies on reducing the environmental load of process industry, and provides knowledge on how to manage environmental issues within the industry by application of proper methods, tools and technologies. The CP orientation was started in September 2009 at the University of Oulu, Finland.

### 2.2.2 Water and Environment

The Water and Environment (WE) orientation includes studies on protection and restoration of natural environment, as well as water and soil pollution, water and waste water treatment, and waste technology. The WE orientation was started in September 2009 at the University of Oulu, Finland.

### 2.2.3 Sustainable Energy

The Sustainable Energy (SE) orientation will answer the need to find green energy solutions for the Barents area environmental conditions. Strong focus is set on hydro-, wind-, solar- and bio-energy technologies, as well as energy efficiency issues in production, distribution and end-use. Orientation will start in September 2010 at the University of Oulu, Finland, as part of the two national Master's programmes of the Department and Environmental Engineering, and will contain a compulsory one-semester-long exchange period at the Narvik University College, Norway.

[4] BEE programme home page, see: http://bee.oulu.fi/index.html

### 2.2.4 **Other orientations**

**Integrated Use of Water Resources** orientation provides knowledge on multi-purpose use of water resources, and proper tools and technologies for water and wastewater treatment for industry and municipalities. Orientation was started in September 2009 at Murmansk State Technical University, Russia.

**Industrial Ecology and Rational Use of Natural Resources** (Environmental technology and management) orientation includes implementation of the green chemistry principles in industry for treating environmental problems, control and assessment and control of environmental state, and environmental management. Orientation will start in September 2010 at The Northern (Arctic) Federal University (NArFU), Russia.

# 3 GENERAL INFORMATION FOR BEE STUDENTS

## 3.1 Degree awarded

Graduating students will be awarded a degree of Master of Science in Engineering from the University where they have been accepted and registered, a diploma supplement from the university where exchange period has been taken, and a BCBU certificate.

## 3.2 Student exchange

Barents Masters Programme in Environmental Engineering contains an exchange period at the BEE Partner University in Norway, Russia or Sweden. In the Clean Production and Water and Environment orientations courses completed during the exchange period can be included in the curriculum's supplementary module. These courses must be agreed in advance with the BEE Student Advisor. In the Sustainable Energy orientation the students from the University of Oulu, the exchange period will be carried out at the Narvik University College, where the second year autumn of the SE orientation is implemented.

# 4 INFORMATION ABOUT THE UNIVERSITY OF OULU, FINLAND

## 4.1 Oulu University Library

The Oulu University Library is divided into many units, of which the most important for BEE students are the course book library Cursus, the science technology library Tellus and the main library Pegasus. All these units of the library are located in the Linnanmaa campus, see the map at http://www.oulu.fi/english/maps.html.

More specific information about Oulu University Library units, opening hours and services is available at www.library.oulu.fi.

## 4.2 Faculty of Technology

The BEE programme is one of the six Master's programmes (of which only BEE belongs to BCBU) organised at the Faculty of Technology, which is the largest of the six faculties of the University of Oulu. It is divided into five departments: Departments of Architecture, Electrical and Information Engineering, Mechanical Engineering, Industrial Engineering and Management, and the Department of Process and Environmental Engineering. The last mentioned is responsible for the BEE programme.

Degrees that can be awarded in the Faculty of Technology are Bachelor of Science in Technology; Master of Science in Technology and Master of Science in Architecture; and Licentiate of Science in Technology and Doctor of Science in Technology as respective postgraduate degrees.

The Faculty administration is managed by the Faculty Council, Dean and two Vice Deans (one for research and one for education). Further, the faculty has Administrative Manager and Student Affairs Manager officials.

Faculty home page http://www.ttk.oulu.fi/English/

The Faculty of Technology with five departments is located at the University of Oulu Linnanmaa campus; see the map link given below in paragraph 4.2.1.

### 4.2.1 Faculty office

Linnanmaa, room YT103, entrance R; see: http://www.oulu.fi/kartat/Linnanmaa_2006_English.pdf
Tel. +358 8 553 1011 (university phone centre) or +358 8 553 2001 / +358 8 553 2002
Office hours 9:00-13:00

### 4.2.2 Faculty personnel

| | |
|---|---|
| *Dean:* | Mr. Kauko Leiviskä |
| *Vice Dean in Education:* | Mrs. Helka-Liisa Hentilä |
| *Administrative Manager:* | Mrs. Laila Kuhalampi |
| *Student Affairs Manager:* | Mrs. Sirpa Nelo |
| *Training Issues Planning Officer:* | Mrs. Simi Outi |
| *Office Personnel:* | Mrs. Liisa Runtti, Mrs. Helena Rimpinen |

## 4.3 Department of Process and Environmental Engineering

The Department of Process and Environmental Engineering (DPEE) carries out high level, techno-scientific research and education with a strong focus on sustainable process, energy and product development. The research profile of the DPEE is unique in Finland, as it combines process and environmental engineering and automation. It conducts research and education in engineering sciences, along all of the focus areas of the University: biotechnology and molecular medicine, information technology and wireless communication, and Northern and environmental issues. The research subjects at the DPEE relate closely to global environmental problems and intend to contribute to Finland's international competitiveness.

The specific strong area of DPEE is its teaching, which is based on unit process thinking. As an acknowledgement for its persistent, long-term development work in teaching, the Department of Process and Environmental Engineering has been awarded the status of National Centre of Excellence in University Education for years 2004-2006, 2007-2009 and 2010-2012 by the Ministry of Education.

The research and education activities of DPEE are divided into eight laboratories, lead by professors: Bioprocess Engineering Laboratory (prof. Heikki Ojamo), Chemical Process Engineering Laboratory (prof. Juha Tanskanen), Control Engineering Laboratory (prof. Kauko Leiviskä), Fibre and Particle Engineering Laboratory (prof. Jouko Niinimäki), Mass and Heat Transfer Process Laboratory, including the Industrial Environmental Engineering unit (prof. Riitta Keiski), Laboratory of Process Metallurgy (prof. Timo Fabritius), System Engineering Laboratory (prof. Enso Ikonen), and Water Resources and Environmental Engineering Laboratory (prof. Björn Klöve).

The Department of Process and Environmental Engineering with its laboratories is located at the University of Oulu Linnanmaa campus.

### 4.3.1 Department office

Linnanmaa, rooms PR112 and PR114, tel. +358 8 553 1011 (university telephone centre)
Department webpage: http://pyo.oulu.fi/ (left column, choose In English)
Tel. +358 8 553 2300

Issues related to all Bachelor's or Master's Degrees in the department are taken care of by the office personnel.

### 4.3.2 Student advisors and tutors

Student advisors give guidance in all different issues related to studies. DPEE has three student advisors for different groups of students: Mrs. Saara Luhtaanmäki (Process and Environmental Engineering students), Mrs. Katri Kosonen (exchange students and student exchange), and the BEE programme Student Advisor Mrs. Marita Puikkonen (room PR165, phone +358 8 553 2309, email marita.puikkonen ät oulu.fi) guiding the BEE Master's Programme students in any issues related to their studies at the University of Oulu and elsewhere.

For the first semester of their studies, the BEE-students at DPEE will also be provided with a student tutor, a peer student to help new students to begin their studies and to become part of

the University community. In addition to initiating the new students to start their studies, they also help with practical issues like visiting various offices. For the new BEE'10 students, the student tutor is Mr. Riku Eskelinen (email reskelin ät mail.student.oulu.fi).

### 4.3.3 Teaching development groups

In the DPEE, there are two official teaching development groups: one for undergraduate studies (Pokki, leader Head of the Department) and another for post-graduate studies (Jopokki, leader Vice Head of the Department). Further, BEE programme has an unofficial teaching development group Beetri for the planning, organising, and forwarding of the programme studies.

### 4.3.4 Personnel in the Department of Process and Environmental Engineering

| | |
|---|---|
| *Head of the Department* | Mr. Jukka Hiltunen |
| *Vice Head of the Department* | Mrs. Riitta Keiski |
| *Student Advisors* | Mrs. Saara Luhtaanmäki (PE, EE) |
| | Mrs. Katri Kosonen (exchange) |
| | Mrs. Marita Puikkonen (BEE) |
| *Office Personnel* | Mrs. Leena Hänninen |
| | Mrs. Kaisu Kallio |
| | Mrs. Hannele Timonen |

Further, the next DPEE (Table A) or University of Oulu (Table B) persons will be responsible for teaching the different BEE programme related courses during the academic year 2010-2011 (situation by 28.6.2010). Contacts by email, addresses: firstname.surname@oulu.fi.

*Table A*

| *Surname* | *First name* | *Surname* | *First name* | *Surname* | *First name* |
|---|---|---|---|---|---|
| Mr. Ahola | Juha | Mr. Kovacs | Jenö | Mrs. Ronkanen | Anna-Kaisa |
| Mrs. Ainassaari | Kaisu | Mr. Kujala | Kauko | Mr. Ruuska | Jari |
| Mr. Huuhtanen | Mika | Mr. Leiviskä | Kauko | Mr. Sallanko | Jarmo |
| Mr. Juuso | Esko | Mr. Muurinen | Esa | Mr. Tanskanen | Juha |
| Mrs. Keiski | Riitta | Mrs. Myllykoski | Hanna | Mrs. Ylönen | Reeta |
| Mr. Klöve | Björn | Mrs. Puikkonen | Marita | | |

Table B

| *Surname* | *First name* | *Unit at the University of Oulu* |
|---|---|---|
| Mr. Juga | Jari | Faculty of Economics and Business Administration |
| Mr. Kess | Pekka | Department of Industrial Engineering and Management |
| Mrs. Palo | Teea | Faculty of Economics and Business Administration |
| Mrs. Pongracz | Eva | Thule Institute |
| Mrs. Sunnari | Vappu | Faculty of Education / Women's and Gender Studies |

### 4.3.5 Studying at the Department of Process and Environmental Engineering

#### 4.3.5.1 Degree programmes

At the DPEE there are two national Bachelor-level programmes, Process Engineering and Environmental Engineering. Respectively, the Master-level programmes at the department are national programmes Process Engineering and Environmental Engineering, and the international Barents Master's Programme in Environmental Engineering. The Master's programme studies are divided to different study orientations and specialisations. See paragraph 2.2 for the BEE programme orientations.

#### 4.3.5.2 Schedules and the structure of the academic year

The academic year is divided into two semesters, autumn semester and spring semester and in the Faculty of Technology and Department of Process and Environmental Engineering, each semester is divided into three periods (periods 1-3 on autumn semester, periods 4-6 on spring semester). The periodical study schedules of the BEE-programme can be found at webpage http://pyo.oulu.fi/index.php?46.

The periods of the study year 2010-2011 are given in the table below. The dates for periods during the academic year 2011-2012 will be announced later. Please note that courses arranged by other departments or faculties are taught according to timetables followed by the arranging units.

| | | |
|---|---|---|
| Autumn '10 | Period 1 | 6.9. - 8.10.2010 |
| | Period 2 | 11.10. - 12.11.2010 |
| | Period 3 | 15.11. - 17.12.2010 |
| Spring '11 | Period 4 | 10.01. - 11.2.2011 |
| | Period 7 | 14.02. - 25.3.2011 |
| | Period 6 | 28.03. - 6.5.2011 |

#### 4.3.5.3 Courses and examinations

The courses have names, codes and extents. The course codes are numbered with six-digit figures and a letter. E.g. courses with the code starting with 488 are organised under the different study options (orientations) in the Environmental Engineering programme, and with 477 under Process Engineering respectively. Code letter A represents subject studies and S advanced studies. For the extents of the courses (ECTS), see the footnote in paragraph 5.

To participate to a course, the students must enrol (register) to them in the WebOodi electronic system (https://weboodi.oulu.fi/), which the University of Oulu students can access after getting their user accounts (email, etc.). Course information can likewise be found at the WebOodi system.

The method of performing a course, i.e. how to pass the course, is always informed by the course organiser / teacher, e.g. the course is performed by lectures, self-studying, and an examination. Also other methods, e.g. seminars or learning portfolios, etc. are implemented.

The most common examination method is a written final exam arranged after the course at the general examination of the DPEE (see the link below for details). The examinations of the department generally last four hours and are arranged on Fridays at noon - 4 p.m. Timetables for the examinations can be found at webpage http://pyo.oulu.fi/studies/examinations.html. Generally, there are two repetitive examinations arranged after the first, so called 'course examination'.

Enrolment to the examinations must be done at the latest two days before the examination at noon in the WebOodi system (see above). Enrolment to the exams is obligatory. Respectively, if the student is unable to participate to the exam, he/she must cancel the enrolment respectively (via WebOodi).

#### 4.3.5.4 **Evaluation and grading of the study performances**

The degrees, separate courses (usually) and the Master's thesis are evaluated by numerical grades Passed 1-5 (1 = satisfactory, 2 = very satisfactory, 3 = good, 4 = very good, 5 = excellent). The grade Failed is represented by 0 for course performances.

#### **4.3.5.5 Personal Study Plan**

During the studies, all students in the BEE programme will follow their Personal Study Plan (PSP) which is based on the official curriculum of their orientation. The PSP is prepared in the beginning of the studies together with the BEE Student Advisor (see paragraph 4.2.3, Student advisors). Any changes to the PSP must be accepted by the BEE Student Advisor. At the end of the studies, the PSP will be ratified in the Faculty, especially if there are significant aberrations in the plan compared to the curriculum.

# 5 THE CURRICULA OF THE BEE MASTER'S PROGRAMME

The orientation (see paragraph 2.2 for descriptions) for the Barents Master's Programme in Environmental Engineering is first preliminary chosen by the student when he/she applies to the programme. The choice is then officially confirmed during the first autumn semester of the studies.

### Structure of the Clean Production and Water and Environment orientations

The quadrangular-model curriculum structure of the two on-going BEE orientations Clean Production (CP) and Water and Environment (WE) is presented in Figure 1. In the quadrangular model, each of the four modules consists of approximately 30 ECTS[5] of courses, making totally 120 ECTS, which is minimally required for the Degree of Master of Science in Technology.

In the first study year, the Basic Option[6] Module (autumn semester) and the Advanced Option Module (spring) contain mostly the same courses in both orientations. The Basic Option Module gives the student the basic knowledge of the orientation, and that knowledge is then further deepened in the Advanced Option and Supplementary Modules. During the second year, the studies are continued with the supplementary courses and Master's thesis. The Supplementary Module (autumn semester) consists of three elective (optional) submodules, chosen from a total of five different for each orientation. Finally, the Master's Thesis work in the second year spring term finishes the studies.

**Master's Degree on Barents Environmental Engineering 120 credits, 2 years**

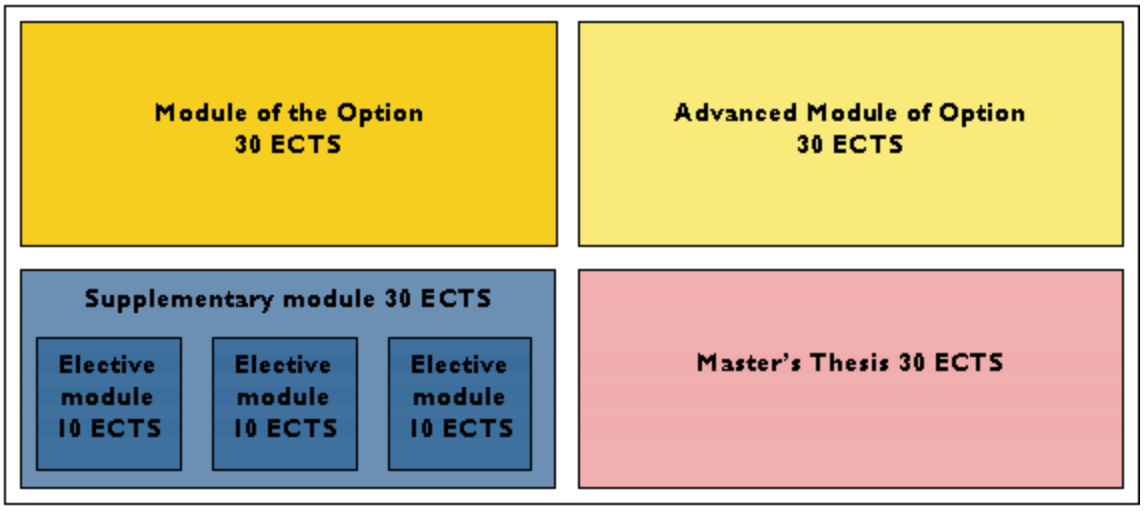


**Fig.1**. The quadrangular-model curriculum structure of the BEE orientations Clean Production and Water and Environment

[5] **ECTS (European Credit Transfer System)**: The workload of studies is expressed in ECTS credits (in Finnish: *opintopiste, op*) that ease the comparison of different studies. One ECTS credit equals to approximately 27 hours of student-studying-work (26 $^{2}/_{3}$ hours exactly). ECTS is a student-centred system based on the student workload required to achieve the objectives of a study programme, preferably specified in terms of the learning outcomes and competences to be acquired. See also http://ec.europa.eu/education/lifelong-learning-policy/doc48_en.htm. Ref: http://www.avoinyliopisto.fi/glossary and http://eacea.ec.europa.eu/erasmus_mundus/tools/glossary_en.php

[6] Option = orientation

## 5.1 Clean Production orientation

### Basic Option Module of Clean Production 30 ECTS

Courses of the Basic Option Module are all compulsory for the students of the orientation. The module contains courses Introduction to the Environmental and Socio-economical Issues of the Barents Region, Introduction to the Environmental Legislative Systems of the Barents Region, and Sustainable Development which are arranged jointly with the other BEE partner universities. The total content of the module is 30 ECTS.

After completing this module the student will have an extensive view of the Barents region and its environmental and socio-economical characteristics. He/she will understand the multidisciplinary nature of global change and sustainable development, and can apply this know-how on the discipline of technology and engineering. The student knows the most important tools for industrial ecology and can apply them in industry. He/she understands the interactions existing between industrial, biological and socio-economical systems.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| 488401A | Introduction to the Environmental and Socio-economical Issues of the Barents Region | 2 | 1-2 |
| 488402A | Sustainable Development | 3 | 3 |
| 488403A | Introduction to the Environmental Legislative Systems of the Barents Region | 5 | 4-6 |
| 477307S | Research Methodology | 5 | 2-6 |
| 488404A | Global Change | 5 | 1-3 |
| 488406A | Introduction to Environmental Science | 5 | 1-3 |
| 488203S | Industrial Ecology | 5 | 2 |
| | **Total** | **30** | |

* Information about the periods according to known situation on 28.6.2010

### Advanced Option Module of Clean Production 30 ECTS

The Advanced Option Module contains both compulsory and optional (elective) studies. The course Environmental Issues in the Barents Region jointly arranged by the BEE partner universities, as well as Advanced Practical Training are compulsory (*) for all CP-orientation students studying at the University of Oulu. Module content should be approximately 30 ECTS, so that the total minimum content of 120 ECTS in the M.Sc. (Tech.) degree will be filled counting this module together with the supplementary module. The student will plan which courses to take, while preparing his/her Personal Study Plan.

After completing the Advanced Option Module courses, the student will recognise the most important causes for industrial environmental load. He/she can apply different methods, tools and technologies onto management of environmental load and to handling other environmental issues in industry.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| 488405S | Environmental Issues in the Barents Region* | 5* | 6 |
| 477203A | Process Design* | 5 | 4-5 |
| 477041S | Experimental Design | 5 | 4 |
| 477311S | Advanced Separation Processes | 4 | 5 |
| 477309S | Environmental and Process Catalysis | 5 | 5 |
| 488104A | Industrial and Domestic Waste Management | 5 | 6 |
| 488205S | Environmental Load of Process Industry | 4 | 6 |
| 488002S | Advanced Practical Training* | 3* | (summer) |
| | **Total** (target) | **36** (~30) | |

## Supplementary Module for Clean Production 3 x 10 ECTS

In the Supplementary Module, the CP-orientation student will select supplementary studies from different submodules 1-5. All the courses are optional (elective). The sum of ECTS of the courses in the three elected submodules should be approximately 30, so that the total content of 120 ECTS in the M.Sc. (Tech.) degree will be filled, counting this module together with the Advanced Module. Please note that the courses in the Submodule 4 (**) are organised by either the Department of Industrial Engineering and Management, or the Faculty of Economics and Business Administration. The other submodules are organised by the Department of Process and Environmental Engineering (or by the BEE partner universities).

After completing the courses chosen for this module, the student will have more specialised knowledge on the chosen subjects. This module aims also to give the student requisites for his/her Master's thesis project.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| **Submodule 1 Energy and Environment** | | | |
| 488202S | Production and Use of Energy | 3 | 1 |
| 488204S | Air Pollution Control Engineering | 5 | 3 |
| **Submodule 2 Control of Phenomena** | | | |
| 477305S | Flow Dynamics | 5 | 2 |
| 477306S | Non-ideal Reactors | 5 | 3 |
| **Submodule 3 Process Design** | | | |
| 477206S | Advanced Process Design | 6 | 2-3 |
| 477503S | Simulation | 3 | 3 |
| **Submodule 4 Economics and Management**** | | | |
| 555321S | Risk Management | 3 | 1-3 |
| 721236A | Principles of Environmental Economics | 5 | 4-5 |
| 721704A | Business logistics | 5 | 2-3 |
| **Submodule 5 Elective Courses** | | | |
| | Optional courses at the BEE partner universities | 10 | 1-3 |
| | **Total** (target) | **(~30)** | |

## Master's Thesis for Clean Production 30 ETCS

The Master's thesis project is an advanced-level study performance of 30 ECTS. The project is planned to be conducted during the second year spring. The student should search for a suitable project self, preferably already during the second year autumn semester at the latest.

The Master's thesis project consists of project research work, literature search etc., and a written thesis. In the BEE programme, the M-thesis is written in English. The Master's thesis project (in Finnish Diplomityö) contains also a compulsory, written maturity test. A maturity test is a written examination, an essay on a topic related to the master's thesis, evaluating the student's ability to write scholarly papers and his/her familiarity with the theories and problems of the thesis. The maturity test must be written without any supporting materials, under supervision. The Master's thesis is evaluated and accepted by the Department of Process and Environmental Engineering.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| | Master's thesis | **30** | 4-6 |

## 5.2 Water and Environment orientation

### Basic Option Module of Water and Environment 30 ECTS

Courses of the Basic Option Module are all compulsory for the students of this orientation. The module contains courses Introduction to the Environmental and Socio-economical Issues of the Barents Region, Introduction to the Environmental Legislative Systems of the Barents Region, and Sustainable Development which are arranged jointly with the other BEE partner universities. The total content of the module is 30 ECTS.

After completing this module the student will have an extensive view of the Barents region and its environmental and socio-economical characteristics. He/she will understand the multidisciplinary nature of global change and sustainable development, and can apply this know-how on the discipline of technology and engineering. The student knows the most important methods for water and waste water treatment in Finland, and can manage the basic practices in the laboratory and field work in environmental engineering.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| 488401A | Introduction to the Environmental and Socio-economical issues of the Barents Region | 2 | 1-2 |
| 488402A | Sustainable Development | 3 | 3 |
| 488403A | Introduction to the Environmental Legislative Systems of the Barents Region | 5 | 4-6 |
| 477307S | Research Methodology | 5 | 2-6 |
| 488118S | Laboratory and Field Measurements in Environmental Engineering | 8 | 1-6 |
| 488110S | Water and Wastewater Treatment | 7.5 | 1-2 |
| | **Total** | **30** | |

* Information about the periods according to known situation on 28.6.2010

### Advanced Option Module of Water and Environment 30 ECTS

The Advanced Option Module contains both compulsory and optional (elective) studies. The course Environmental Issues in the Barents Region jointly arranged by the BEE partner universities, as well as Advanced Practical Training are compulsory (*) for all WE-orientation students studying at the University of Oulu. Module content should be approximately 30 ECTS, so that the total minimum content of 120 ECTS in the M.Sc. (Tech.) degree will be filled, counting this module together with the supplementary module. The student will plan which courses to take, while preparing his/her Personal Study Plan (see paragraph 4.3.5.5).

After completing this module, the student will recognise the most important causes for environmental load especially in the Barents region and can apply different methods, tools and technologies in controlling and reducing harmful environmental effects. The student also understands the natural phenomena and processes related to water resources.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| 488405S | Environmental Issues in the Barents Region* | 5* | 6 |
| 477041S | Experimental Design | 5 | 4 |
| 477203A | Process Design | 5 | 4-5 |
| 477311S | Advanced Separation Processes | 4 | 5 |
| 488102A | Hydrological Processes | 6 | 1-6 |
| 488104A | Industrial and Domestic Waste Management | 5 | 6 |
| 488002S | Advanced Practical Training* | 3* | (summer) |
| | **Total** (target) | **33** (~30) | |

## Supplementary Module for Water and Environment 3x10 ECTS

In the Supplementary Module, the WE-orientation student will select supplementary studies from different submodules 4-8. All the courses are optional (elective). The sum of ECTS of the courses in the three elected modules should be approximately 30, so that the total content of 120 ECTS in the M.Sc. (Tech.) degree will be filled, counting this module together with the advanced module. Please also note that the courses in the Submodule 4 (**) are organised by either the Department of Industrial Engineering and Management, or the Faculty of Economics and Business Administration. The other submodules are organised by the Department of Process and Environmental Engineering (or by the BEE partner universities).

After completing the courses chosen for this module, the student will have more specialised knowledge on the chosen subjects. This module aims also to give the student requisites for his/her Master's thesis project.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| **Submodule 4 Economics and Management**** | | | |
| 555321S | Risk Management | 3 | 1-3 |
| 721236A | Principles of Environmental Economics | 5 | 4-5 |
| 721704A | Business logistics | 5 | 2-3 |
| **Submodule 5 Elective Courses** | | | |
| | Optional courses at the BEE partner universities | 10 | 1-3 |
| **Submodule 6a Water 1** (available only on odd years: 2011, 2013) | | | |
| 488108S | Groundwater Engineering | 5 | 1-2 |
| 488117S | Water Resources Management | 7.5 | 2-3 |
| **Submodule 6b Water 2** (available only on even years: 2010, 2012) | | | |
| 488103A | Environmental Impact Assessment | 5 | 2-3 |
| 488113S | Hydraulics for Environmental Engineering | 5 | 2-3 |
| **Submodule 7 Geoenvironmental engineering** | | | |
| 488106A | Basics in Geo-environmental Engineering | 5 | 2-3 |
| 488115S | Advanced Geo-environmental Engineering | 5 | 4-5 |
| **Submodule 8 Environmental Systems** | | | |
| 488203S | Industrial Ecology | 5 | 2 |
| 488404A | Global Change | 5 | 1-3 |
| | **Total** (target) | **(~30)** | |

## Master's Thesis for Water and Environment 30 ECTS

The Master's thesis project is a advanced-level study performance of 30 ECTS. The project is planned to be conducted during the second year spring. The student should search for a suitable project self, preferably already during the second year autumn semester at the latest. The Master's thesis project consists of an project research work, literature search etc., and a written thesis. In the BEE programme, the M-thesis is written in English. The Master's thesis project (in Finnish Diplomityö) contains also a compulsory, written maturity test. A maturity test is a written examination, an essay on a topic related to the master's thesis, evaluating the student's ability to write scholarly papers and his/her familiarity with the theories and problems of the thesis. The maturity test must be written without any supporting materials, under supervision. The Master's thesis is evaluated and accepted by the Department of Process and Environmental Engineering.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| | Master's thesis | **30** | 4-6 |

## 5.3 Structure of the Sustainable Energy orientation

The Sustainable Energy (SE) orientation will start in September 2010 at the University of Oulu, Finland, as part of the two national Master's programmes of the Department and Environmental Engineering. The quadrangular-model curriculum structure of the SE-orientation is presented in Figure 2. In the quadrangular model, each of the four modules consists of approximately 30 ECTS of courses, making totally 120 ECTS, which is minimally required for the Degree of Master of Science in Technology.

In the first Master's study year (the fourth year of the complete studies), the student will take the Basic Option Module (on autumn semester) and the Advanced Option Module (on spring semester). The Orientation module gives the student the basic knowledge of the SE-orientation, and that knowledge is then further deepened in the Advanced Option and Supplementary Modules. During the second Master's year, the studies are continued with the supplementary courses and Master's thesis. The Supplementary Module (autumn semester) consists of two submodules and is done in Norway, in the Narvik University College. Finally, the Master's Thesis work in the second year spring term finalizes the studies.

**Masters Degrees on Process or Environmental Engineering, orientation Sustainable Energy 120 credits, 2 years**

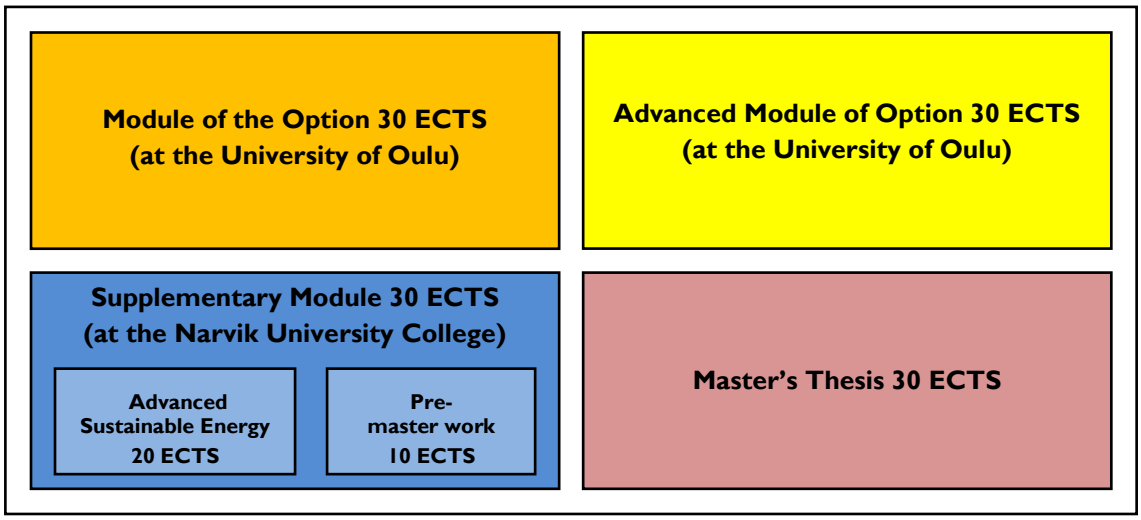


**Fig.2.** The quadrangular-model curriculum structure of the Sustainable Energy orientation

### Basic Option Module of Sustainable Energy 30 ECTS

Courses of the Basic Option Module are all compulsory for the students of the orientation. The module contains courses Introduction to the Environmental and Socio-economical Issues of the Barents Region, Introduction to the Environmental Legislative Systems of the Barents Region, Sustainable Development and Global Change, which are arranged jointly with the other BEE partner universities. The total content of the module is 30 ECTS and it will be carried out at the University of Oulu.

After completing this module, the student will have an extensive view of the Barents region and its environmental and socio-economical characteristics. He/she will understand the multi-disciplinary nature of global change and sustainable development, and can apply this know-how on the discipline of technology and engineering. The student knows the most important tools for industrial ecology and can apply them in industry. He/she understands the interactions existing between industrial, biological and socio-economical systems. In addition, the student can manage

the basics of the production, delivery and use of energy, and is familiar to the structure of the energy markets in Finland. He/she will also recognise the questions related to the most important energy sources, their delivery and sufficiency, and environmental protection.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| 488401A | Introduction to the Environmental and Socio-economical Issues of the Barents Region | 2 | 1-2 |
| 488402A | Sustainable Development | 3 | 3 |
| 488403A | Introduction to the Environmental Legislative Systems of the Barents Region | 5 | 4-6 |
| 488404A | Global Change | 5 | 1-3 |
| 477321S | Research Ethics | 2 | 4 |
| 488202S | Production and Use of Energy | 3 | 1 |
| 488203S | Industrial Ecology | 5 | 2 |
| 488204S | Air Pollution Control Engineering | 5 | 3 |
| | **Total** | **30** | |

* Information about the periods according to known situation on 28.6.2010

### Advanced Option Module of Sustainable Energy 30 ECTS

The Advanced Option Module contains both compulsory and optional (elective) studies. The courses *Environmental Issues in the Barents Region* jointly arranged by the BEE partner universities and *Introduction to the Sustainable Energy* provided by Narvik University College, as well as course *Advanced Practical Training* are compulsory (*) for all SE-orientation students studying at the University of Oulu. Module content should be approximately 30 ECTS, so that the total minimum content of 120 ECTS in the M.Sc. (Tech.) degree will be filled, counting this module together with the supplementary module. The student will plan which courses to take, while preparing his/her Personal Study Plan.

After completing the Advanced Option Module courses, the student will recognise the most important causes for industrial environmental load. He/she can apply different methods, tools and technologies onto the management and reduction of harmful environmental effects. The student is familiar with the most common systems in energy production and energy delivery and can define the most important environmental loads caused by them. He/she knows the distinctive characters, and is able to estimate the environmental effects of sustainable energy, and compare the benefits, possibilities and consequences of the different energy production and delivery systems.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| 488405S | Environmental Issues in the Barents Region* | 5* | 6 |
| 488410A | Introduction to Sustainable Energy* | 10* | 5 |
| 477041S | Experimental Design | 5 | 4 |
| 477309S | Environmental and Process Catalysis | 5 | 5 |
| 477311S | Advanced Separation Processes (next on spring 2012!) | 4 | 5 |
| 488104A | Industrial and Domestic Waste Management | 5 | 6 |
| 488205S | Environmental Load of Process Industry | 4 | 6 |
| 488002S | Advanced Practical Training* | 3* | (summer) |
| | **Total** (target) | **41** (30) | |

## Supplementary Module for Sustainable Energy 30 ECTS

The Supplementary Module for the Sustainable Energy orientation will be carried out at the Narvik University College, Norway, during the autumn semester of the fifth study year (second Master's degree year). The module consists of two compulsory submodules and the total content of the module is 30 ECTS.

After completing this module, the student will extensively manage the sustainable energy related technologies applied in industry. He/she will also master the energy efficiency and energy conservation strategies involved in construction at the Northern regions. This module aims also to give the student requisites for his/her Master's thesis project.

| Code | Course name | ECTS | Periods* |
|---|---|---|---|
| **Submodule 9 Advanced Sustainable Energy** | | | |
| 488420S | Solar and Wind Energy | 10 | 1-3 |
| 488421S | Bio-Energy | 5 | 1-3 |
| 488422S | Energy Systems in Buildings and Industry | 5 | 1-3 |
| **Special Module 10 Pre-master work** | | | |
| 488423S | Project work – Sustainable energy | 10 | 1-3 |
| | **Total** | **30** | |

## Diploma thesis for Sustainable Energy 30 ECTS

The Master's thesis project is an advanced-level study performance of 30 ECTS. The project is planned to be conducted during the second Master's year spring. The student should search for a suitable project self, preferably already during the second year autumn at the latest. The Master's project of the Sustainable Energy orientation student can be conducted either in Finland or in Norway, depending on the subject of the thesis.

The Master's thesis project consists of a project research work, literature search etc., and a written thesis. The Master's thesis project (in Finnish Diplomityö) contains also a compulsory, written maturity test. A maturity test is a written examination, an essay on a topic related to the master's thesis, evaluating the student's ability to write scholarly papers and his/her familiarity with the theories and problems of the thesis. The maturity test must be written without any supporting materials, under supervision. The Master's thesis is evaluated and accepted by the Department of Process and Environmental Engineering.

| Code | Course name | ECTS | Periods |
|---|---|---|---|
| | Master's thesis | **30** | 4-6 |

# 6 COURSE DESCRIPTIONS

In the next paragraphs the courses belonging to the BEE programme curricula are described. The courses by the different BEE partner universities are described, and the information is given, according to available information on summer 2010. For more up-to-date info about the University of Oulu courses, please also see the course descriptions in the WebOodi system (https://weboodi.oulu.fi/oodi/) or contact your Study Advisor.

Please note that in the descriptions Period refers to the periodical course schedule of the Faculty of Technology (see paragraph 4.3.5.2), and Scope is the number of ECTS for the described course. Check the status of the courses (obligatory/optional, etc.) from your curriculum. If not otherwise stated, the course language (language of instruction) is English.

## 6.1 COURSES IN UNIVERSITY OF OULU, FINLAND

### 6.1.1 Department of Process and Environmental Engineering, Faculty of Technology

#### 488401A Introduction to the Environmental and Socio-economical Issues of the Barents Region

**Timing:** Autumn, periods 1-2
**Scope:** 2 ECTS
**Responsible person:** Marita Puikkonen and Hanna Myllykoski
**Objective:** This course provides an introduction to the Barents region, including its history and culture, and clarifies the main environmental and socio-economic incentives to the need of the Barents Environmental Engineering programme.
**Learning outcomes:** Student will understand the main environmental and socio-economic issues of the Barents region.
**Contents:** History of the international cooperation between the areas along the coast of the Barents Sea, introduction to the environmental profile of the region, industry and infrastructure, people and cultures; Presentation of the Barents Cross-Border University project, the universities participating the Barents Environmental Engineering Programme and orientations in the programme; Showcasing the main focus areas of research and education in the BEE universities.
**Working and assessment methods:** Lectures, self-studying and learning portfolio.
**Study materials:** Material provided during the course.

#### 488402A Sustainable Development

**Timing:** Autumn, period 3
**Scope:** 3 ECTS
**Responsible person:** Hanna Myllykoski
**Objective:** To provide an understanding of the multidisciplinary nature and concept of sustainability and to clarify the patterns of resources use and the limits of the carrying capacity of natural systems; to outline the future perspectives on the prosperity of social and economic systems.
**Learning outcomes:**
**Contents:** Multidisciplinary, intensive and interactive course with pre-course and post-course assignments. Presentations on: Principles of sustainable development; Environmental justice (human rights, minority rights); Economic development and sustainability (poverty and equity); Social development and culture; Corporate sustainability or corporate social responsibility.
**Working and assessment methods:** Lectures, case studies, negotiation simulations, group projects. Course evaluation will be based on activity during the seminar and post-course assignment.
**Study materials:** Material provided during the course.

### 488403A Introduction to the Environmental Legislative Systems of the Barents Region

**Timing:** Spring, periods 5-6.
Please note that this course is currently under construction – e.g. the name, contents and working methods may change!
**Scope:** 5 ECTS
**Responsible person:** Anna Kaisa Ronkanen
***Objective:*** *To provide an understanding of the structure and differences between the legislative systems of EU, Finland, Norway and Russia.*
***Learning outcomes:*** *Students have the skills to find relevant sources of information and apply current legislation.*
***Contents:*** *A roadmap of the legislative systems, especially sources from where relevant information can be found. Exercises to solve problem-based case-studies related to implementing legislation, especially in a cross-border cooperative environment, as well as comparing the different systems across the Barents region.*
***Working and assessment methods:*** *Lectures and exercises.*
***Study materials:*** *Sources of material provided during the course.*
***Other information:*** *This course is organised in the BEE partner university context*
***Language of instruction:*** *English (parts for BEE students)*

### 488404A Global Change

**Timing:** Autumn, periods 1-2
**Scope:** 5 ECTS
**Responsible person:** Ali Torabi Haghihgi
**Objective:** To introduce and describe the basic concepts in global change.
**Learning outcomes:** Students are able to describe the concept of global change, and to critically evaluate information available on global change.
**Contents:** The basic concepts in global change: Overview of global change past, present and future perspectives; Method and tools for assessment, scenarios of future change; Overview of some climate change evidences such as global warming, sea level rising, melting glaciers, greenhouse gases, acid raining, ozone hole and so on; Evaluating the global change reasons (natural and human reasons); Evaluating the global change effect on water resource, health, aquatic ecosystems and their goods and services; Global change adaptation in context of sustainable development.
**Working and assessment methods:** Classroom discussions, student group work, extra literature survey, two reports, two presentations; learning diary. Assessment is based on the performance of the different assignments listed before, grades 1-5.
**Study materials:** Sources of material provided during the course.

### 488405S Environmental Issues in the Barents Region

**Timing:** Spring, period 6
**Scope:** 5 ECTS
**Responsible person:** Eva Pongracz, with the international BEE lecturer team
**Objective:** To provide the student with a comprehensive understanding of the environmental landscape of the Barents region, the impacts of past activities, and projections of future economic and social development.
**Learning outcomes:**
**Contents:** Northern land-use, Diversity of the northern environment, Land-use and socio-economical changes, Sustainable use of northern resources (forest resources, minerals, Barents Sea resources), Global change in the north, Industry and pollution (prevention and remediation), Socio-economic issues (health, indigenous cultures, languages).
**Working methods:** Contact teaching, field-trip and course assignments.
**Location:** Oulanka Research Station.
**Study materials:** Material provided during and prior to the course

### 488406A Introduction to Environmental Science

**Timing:** Spring, periods 4-6
**Scope:** 5 ECTS
**Responsible person:** Virpi Väisänen prof. Riitta Keiski

**Objective:** The aim of the course is to familiarize the student with the principles of environmental science.
**Learning outcomes:** The student is able to define the basic concepts of environmental ecology. He/she has knowledge about the state of environment and is able to explain the essential environmental problems and the main effects of pollution. In addition, the student knows some solutions to the environmental problems and is aware about ethical thinking in environmental engineering.
**Contents:** Principles of environmental ecology. Roots of environmental problems. Global air pollution: ozone depletion, acid deposition, global warming and climate change. Water pollution, eutrophication, overexploitation of ground and surface water. Main effects of pollution and other stresses. Non-renewable and renewable energy. Energy conservation and efficiency. Hazardous and solid waste problem. Principles of toxicology and risk assessment. Environmental ethics.
**Working and assessment methods:** Self-study (book reading) and e-learning tasks in the Optima virtual learning environment, and exam. Please note that this course is arranged together with the course 488201A Environmental Ecology.
**Study materials:** Chiras D.: Environmental Science: Creating a Sustainable Future. New York, Jones and Bartlett Publishers, 2001.

### 477041S Experimental Design

**Timing:** Spring, period 4
**Scope:** 5 ECTS
**Responsible person:** Prof. Kauko Leiviskä
**Objective:** To provide the student with understanding of the measurements uncertainty evaluation and calculation as well as ideas of implementing this information in experimental and computational research and measurements.
**Learning outcomes:** After this course the student knows the main software tools for experiment design and is able to use them. He can apply the main approaches for studying and evaluating the measurement reliability.
**Contents:** Determining the uncertainty of measurements in chemical, physical and biochemical measurements, measurements reliability and traceability; Calculation examples supporting the learning of measurements uncertainty assessment preparation; Experimental design software (Modde, Minilab, Matlab tools); Experimental design preparation and execution in laboratory scale research. Test methods and variable significance, reliability of experimental data; Problems in laboratory, pilot and full scale experiments, problems in modelling and in simulation.
**Working and assessment methods:** Lectures and practical work. Assessment during the course, by continuous evaluation with lecture exams, and written report of the practical work
**Study materials:** Material given in the lectures.

### 477203A Process Design

**Timing:** Spring, period 4-5
**Scope:** 5 ECTS
**Responsible person:** Juha Ahola
**Objective:** Student gets a general view on process design, the activities of design organizations, and the knowledge and skills needed in each design task.
**Learning outcomes:** By completing the course the student is able to identify the activities of process design and the know-how needed at different design stages. The student can utilise process synthesis and analysis tools for creating a preliminary process concept and point out the techno-economical performance based on holistic criteria.
**Contents:** Acting in process design projects, safety and environmentally conscious process design. Design tasks from conceptual design to plant design, especially the methodology for basic and plant design. Assessment: Combination of examinations and group exercises.
**Working and assessment methods:** A chain of design exercises to practice the designing of a process, supported by contact learning and web-based learning environment. Assessment by the reports of the group exercises and short theory, and exams performed as individuals.
**Study materials:** Lecture handout. Seider, W.D., Seider, J.D. and Lewin, D.R.: Process Design Principles Synthesis, Analysis and Design. John Wiley & Sons, 1999. (Parts). **Language of instruction:** English

**477206S Advanced Process Design**

**Timing:** Autumn, period
**Scope:** 6 ECTS
**Responsible person:** Prof. Juha Tanskanen
**Objective:** To develop students skills to work as a member in an industrial chemical process design project. The students will experience by team work the hierarchical character of the conceptual process design, the benefits of the systematic working methods and the need to understand the whole process performance when optimal design is sought. The importance of innovation and creative work is emphasized.
**Learning outcomes:** The student is able to produce a preliminary chemical process concept. She/he can apply systematic process synthesis tools, chemical process simulation tools and whole process performance criteria in the conceptual process design phase. Furthermore, the student is able to produce process design documents. The student will acquire skills how to work as a member in an industrial chemical process design project. She/he will experience by team work the hierarchical character of the conceptual process design, the benefits of the systematic working methods and the need to understand the whole process performance when optimal design is sought. The student understands the importance of innovation and creative work.
**Contents:** Conceptual process design and hierarchical decision making. Heuristics of process design. Design methodology: synthesis, analysis and evaluation. Design cycle. Performance evaluation of the chemical processes. Team work and meetings.
**Working and assessment methods:** Design projects in small groups.
**Study materials:** Seider W.D. Seader J.D. & Lewis D.R.: Process Design Principles Synthesis, Analysis and Design. John Wiley & Sons, 1999

**477305S Flow Dynamics**

**Timing:** Autumn, period 2
**Scope:** 5 ECTS
**Responsible person:** Esa Muurinen (lectures), Reeta Ylönen (exercises)
**Objective:** To familiarize the student with mathematical modeling of flow phenomena using computational fluid dynamics (CFD) and experimental validation of the results.
**Contents:** Equations in fluid dynamics. Partial differential equations. Difference method. Graphical representation. Modelling the turbulence. Finite element method. Finite volume method. Measurement techniques for flow properties. Fluid mechanical apparatus.
**Working and assessment methods:** Lectures and compulsory exercises done in small groups. Examination.
**Study materials:** Anderson J.D.: Computational Fluid Dynamics, McGraw-Hill, 1995; Versteeg H.K. & Malalasekera W.: An Introduction to Computational Fluid Dynamics, Longman Scientific and Technical, 1995; Tavoularis S.: Measurement in fluid mechanics, Cambridge University Press, 2005.
**Additional literature:** Shaw C.T.: Using Computational Fluid Dynamics, Prentice Hall, 1992; Nakayama Y. & Boucher R.F.: Introduction to Fluid Mechanics. Arnold, 1999; Rathakrishnan E.: Instrumentation, measurements, and experiments in fluids. CRC Press, 2007.
**Language of instruction:** English (exercises and exam)

**477306S Non-ideal Reactors**

**Timing:** Autumn, period 3
**Scope:** 5 ECTS
**Responsible teacher:** Prof. Riitta Keiski, Mika Huuhtanen
**Objective:** By means of the residence time distribution theory, students adopt a way of thinking in modelling which is based on the concept of probability.
**Learning outcomes:** After completing the course the student can analyze the effect of non-ideal mixing conditions on the behaviour of a reactor. He/she is capable of explaining the mechanisms of heterogeneous reactions, especially with methods that are used to analyze the effect of mass and heat transfer on kinetics of heterogeneous reactions. The student has rudimentary skills to do demanding reactor analysis and to design heterogeneous reactors.

**Contents:** Mixing models of a flowing material. Residence time distribution theory. Heterogeneous catalysis and biochemical reactions: mechanisms, mass and heat transfer, and reactor design. Gas-liquid reactions: mechanisms, mass transfer, and reactor design. Design heuristics. Microreactors.
**Working and assessment methods:** Lectures including exercises. Examination.
**Study materials:** Nauman E.B.: Chemical Reactor Design. New York, John Wiley & Sons. 1987; Winterbottom J.M. & King M.B. (Editors) Reactor Design for Chemical Engineers. Padstow, T.J. International Ltd.,1999.
**Additional literature:** Gianetto A. & Silveston P.L.: Multiphase Chemical Reactors: Theory, Design, Scale-up. Hemisphere, Washington, D. 1986; Froment G. & Bischoff K.B.: Chemical Reactor Analysis and Design. New York, John Wiley & Sons. 1990; Hessel V., Hardt S. & Löwe H.: Chemical Micro Process Engineering. Weinheim 2004, Wiley-VHC Verlag GmbH & Co.

### 477307S Research Methodology

**Timing:** Autumn, Spring, periods 2-6
**Scope:** 5 ECTS
**Responsible teacher:** Mika Huuhtanen and other researchers
**Objective:** To familiarize the student with scientific research, scientific methods and data handling, especially in process and environmental engineering. The course will give the student the basis to do the research work and motivates him/her to post-graduate studies. The course gives the student skills for team work and increases the co-operation between the students and the research and teaching staff. The students are given experiences on co-operation between different fields of science, industry, and other universities and laboratories, as well as the skills for doctoral studies.
**Learning outcomes:** After the course the student is able to identify the role of research and different stages of research work. The student can classify the stages and the subtasks of research work as well as important elements related to research, i.e. literature search, experimental work, and data processing. In addition, the student can evaluate the amount of work needed in research stages. The student can write scientific text and use references appropriately. The student also has ability to recognize ethical issues related to the research and analyze the meanings of those. He/she can identify the principles of good scientific practices and is able to apply knowledge on research work.
**Content:** 1) Science and research politics. 2) Research education. 3) Fundamentals of philosophy of science. 4) Starting a research work: research types, funding, the process of research work, finding the research area, choosing the research topic, information sources. 5) Research plan and collecting data, experimental methods and significance of the variables, systematic experimental design, collecting experimental data, test equipments, reliability of the results, problems in laboratory experiments, modelling and simulation. 6) Mathematical analysis of results. 7) Reporting: writing a scientific text, referring, writing diploma, licentiate and doctoral theses, or reports. 8) Other issues connected to research work: ethical issues, integrity, and future. 9) Examples of scientific research in practice.
**Working and assessment methods:** Lectures, teaching in groups, project operation and demonstrations.
**Study materials:** Melville S. & Goddard W.: Research Methodology; An Introduction for Science and Engineering Students. Kenwyn 1996, Juta & Co. Ltd.; Material introduced in the lectures.
**Additional literature:** Paradis J.G. & Zimmermann M.L.: The MIT Guide to Science and Engineering Communication, 2nd ed. Cambridge 2002, The MIT Press.

### 477321S Research Ethics

**Timing:** Spring, period 4
**Scope:** 2 ECTS
**Responsible person:** prof. Riitta Keiski
**Learning outcomes**: After the course the student is capable of explaining the meaning of research ethics and good scientific practice including honesty, conscientiousness and precision in research work. The student is able to plan, carry out and report his/her research work, and is aware of the rights and duties of a researcher and their actions and respect towards other researchers. The student is able to recognise misconduct and fraud in scientific practices and has an awareness of how to handle misconduct.
The student is able to define the basic concepts of environmental ecology. He/she has knowledge about the state of environment and is able to explain the essential environmental problems and the main effects of pollution. In addition, the student knows some solutions to the environmental problems and is aware about ethical thinking in environmental engineering.

**Contents**: Ethically good research. Scientific community and ethical problems in research work. Professional ethics of a researcher and an engineer. Good scientific practices and handling of misconduct and fraud in science. Regulations and rules. Definitions, Characteristic features of science, Research results and responsible persons in scientific work, Ethics and research ethics, Professional ethics of a researcher, Research ethics in Finland and globally, Instructions for preventing, handling and examining misconduct and fraud in good scientific practices and scientific research, Good scientific practices and responsibility in performing research, Good practices in selecting the research problem, collecting the material, planning and performing the research, publishing, using and applying the results, Protection of a researcher under the law, Examples and statistics.
**Working and assessment methods**: Lectures and team work. Examination or a learning diary.
**Study materials:** Good scientific practice and procedures for handling misconduct and fraud in science. Helsinki 2002, TENK, National Advisory Board on Research Ethics., Guidelines for the Prevention, Handling and Investigation of Misconduct and Fraud in Scientific Research. Helsinki 1998, TENK, National Advisory Board on Research Ethics., Martin, M.W. & Schinzinger, R. Ethics in Engineering, 4th Edition. New York, 2005, McGraw Hill Co. 339 p.

### 477309S Environmental and Process Catalysis

**Timing:** Spring, period 5
**Scope:** 5 ECTS
**Responsible person:** Mika Huuhtanen, prof. Riitta Keiski
**Objective:** Introducing the history, principles of green engineering and the application of environmental catalysis, design, and selection and testing of catalysts and catalytic reactors and processes, and the most important industrial catalytic processes.
**Learning outcomes:** After the course the student is able to present the fundamentals and history of catalysis and he/she can explain economical, environmental and technical meaning of catalysis. The student is capable of specifying the design, selection and testing of catalysts and catalytic reactors and processes. He/she is able to explain the most important industrial catalytic processes, the use of catalysts in environmental technology, catalyst research and the significance of interdisciplinary approach in the preparation, development and use of catalysts. He/she recognizes the connection between catalysis and green chemistry and the role of catalysis in sustainable processes and energy production.
**Contents:** Definition of catalysis and a catalyst, history of catalysis, economical, social and environmental meaning. Preparation of catalysts, principles, selection, design and testing of catalysts and catalytic reactors. Kinetics and mechanisms of catalytic reactions, catalyst deactivation. Industrially important catalysts, catalytic reactors and catalytic processes. Environmental catalysis. Catalysts in air pollution control and purification of waters and soil. Catalysis and green chemistry. Catalysis for sustainability. Principles in the design of catalytic processes.
**Working and assessment methods:** Lectures including design exercises. Examination.
**Study materials:** Lecture handout; Richardson J.T.: Principles of Catalyst Development. New York. 1989; Janssen F.J.J.G. & van Santen R.A.: Environmental Catalysis. NIOK, Catalytic Science Series, Vol. 1. 1999.
**Additional literature:** Ertl G., Knözinger J. & Weitkamp J.: Handbook of Heterogeneous Catalysis. Vol. 1-5. Weinheim. 1997; Thomas J.M. & Thomas W.J.: Principles and Practice of Heterogenous Catalysis. Weinheim 1997; Somorjai G.A.: Surface Chemistry and Catalysis. New York 1994; van Santen R.A., van Leuwen P.W.N.M., Mouljin J.A. & Averill B.A.: Catalysis: An Integrated Approach, 2nd ed. Studies in Surface Science and Catalysis 123. Amsterdam 1999, Elsevier Sci. B.V.

### 477311S Advanced Separation Processes

**Timing:** Spring, period 5 (please note: next time on spring 2010)
**Scope:** 4 ECTS
**Responsible person:** Kaisu Ainassaari, prof. Riitta Keiski
**Objective:** The course reviews the recent methods and techniques for separating and purifying components and products e.g. in chemical, food, biotechnology industry. The course introduces new research innovations in separation processes.
**Learning outcomes:** After completing the course the student can review the recent methods and techniques for separation and purification of components and products e.g. in chemical, food, biotechnology industry. He/she masters the principles of green separation processes and their research status and potentiality in industrial applications.

**Contents:** The course is divided into lectures given by visiting experts from different fields (industry, research institutes and universities) and seminars given by students and senior researchers. The lectures open up the newest innovations in separation and purification technologies. The lectures can include for example the following themes: Phenomena in Supercritical fluid extraction, Pressure-activated membrane processes, Reverse osmosis, Nanofiltration, Ultrafiltration, Microfiltration, Pervaporation, Polymer membranes, Dialysis, Electrolysis and Ion-exchange, Forces for adsorption and Equilibrium adsorption isotherms, Sorbent materials and heterogeneity of surfaces, Predicting mixture adsorption, Rate processes in adsorption/adsorbers and adsorber dynamics, Cyclic adsorption processes, Temperature and pressure swing adsorption. Innovative separation methods, Phenomena integration, New hybrid materials as separation agents. Fluids and their application in gas extraction processes, Solubility of compounds in supercritical fluids and phase equilibrium. Extraction from solid substrates: Fundamentals, hydrodynamics and mass transfer, applications and processes (including supercritical water and carbon dioxide). Counter-current multistage extraction: Fundamentals and methods, hydrodynamics and mass transfer, applications and processes. Solvent cycles, heat and mass transfer, methods for precipitation. Supercritical fluid chromatography. Membrane separation of gases at high pressures. The topics of the course seminars will change annually depending on the research relevance.
**Working and assessment methods:** Lectures during period 5. With the lectures the students will familiarize themselves to the latest research publications. Seminars. Examination. Please note, that the course is arranged every second year.
**Study materials:** The course literature will be chosen when the course is planned. Latest scientific research articles.
**Additional literature:** Separation Processes in the Food and Biotechnology Industries, Edited by: Grandison, A.S. & Lewis, M.J. 1996 Woodhead Publishing.

### 488102A Hydrological Processes

**Timing:** Self-studies after instruction, timetable not fixed
**Scope:** 5 ECTS
**Responsible person:** Prof. Björn Klöve, university lecturer Anna-Kaisa Ronkanen
**Objective:** To provide a basic understanding of water flow and storage processes involved in the hydrological cycle and provide an introduction to engineering computational methods used to manage water resources in natural and manmade environments.
**Contents:** Hydrological cycle, physical properties of water, distribution of water resources, water balance, precipitation, evapotranspiration, soil and ground water, infiltration, runoff, snow hydrology, hydrometry, water quality, rivers and lakes.
**Learning outcomes:** The student will be able to explain the main hydrological processes quantitatively through mathematical methods-
**Working and assessment methods:** Self study after instruction.
**Study materials:** Given later (upon request)
**Prerequisites:** Material and Energy Balances (recommended)

### 488103A Environmental Impact Assessment

**Timing:** Autumn, periods 2-3
**Scope:** 5 ECTS
**Responsible person:** Prof. Björn Klöve
**Objective:** To provide a broad and multidisciplinary and sustainable approach to environmental impact assessment (EIA).
**Learning outcomes:** The student will understand the EIA process and the different methods used in environmental assessment.
**Contents:** EIA process and legislation, environmental change, principles and assessment methods in ecology, hydrology, economics and social sciences.
**Working and assessment methods:** The course is organised in a co-operation with the Faculties of Technology, Economics, Social Sciences, and Biology and the Thule institute. **Study materials:** Lecture and exercise materials.
**Prerequisites:** Basic courses in economics (recommended), environmental sciences or engineering (recommended).
**Other information:** Organised every other year (on even years).

### 488104A Industrial and Domestic Waste Management

**Timing:** Spring, period 6
**Scope:** 5 ECTS
**Responsible person:** Anna-Kaisa Ronkanen
**Objective:** Introduction to waste management legislation, management methods, technical principles and terminology.
**Learning outcomes:** Student can explain main things about waste management legislation. Student can describe how the waste amount can be diminished and how waste can be recycled and utilized. Furthermore, student can describe optimisation methods of waste management processes.
**Contents:** EU and Finnish legislation, control of waste flows and amounts, recycling and utilisation, sorting and logistics, hazardous waste, environmental protection.
**Study materials:** Lectures, exercises, and field visits.
**Course literature:** Will be announced later.
**Other information:** Course name in the WebOodi system (https://weboodi.oulu.fi/oodi/) "Industrial and Communal Waste Management"

### 488106A Basics in Geoenvironmental Engineering

**Timing:** Autumn, periods 1-2
**Scope:** 5 ECTS
**Responsible person:** Kauko Kujala
**Objective:** To make the student familiar with the behaviour of detrimental elements in soil. Make the student acquainted with restoring the geologic environment and restraining the damages and also exploiting the industrial by-products in soil structures.
**Contents:** Soil as intermediate agent. Contaminant transfer in soil. Remediation of contaminated soil and purifying ground water. Final disposal sites for waste. Exploitation of industrial by-products and geo-environment in industry.
**Working and assessment methods:** Lectures. Exercises. Seminar.
**Study materials:** Lecture handout and material given in lectures.
**Prerequisites:** Course Introduction to Environmental Engineering (recommended)
**Other information:** Course name in the WebOodi system (https://weboodi.oulu.fi/oodi/) "Basics in Environmental Geotechnics".

### 488108S Groundwater Engineering

**Timing:** Autumn, periods 1-2
**Scope:** 5 ECTS
**Responsible person:** Professor Björn Klöve
**Objective:** To acquire knowledge on water retention and flow in soils, hydraulics of ground water systems, ground water quality, ground water use and modelling.
**Learning outcomes:** The student will understand hydraulic properties of porous media and aquifers and the main methods used to describe and simulate flow processes in ground water.
**Contents:** Soil and ground water, aquifers, water balance, hydraulic properties of soils, formation of ground water, flow equations and solutions, pumping tests and methods, groundwater vulnerability, ground water directive, ground water dependent ecosystems, ground water quality and modelling.
**Working and assessment methods:** Lectures, soil laboratory work, modelling (GMS-MODFLOW).
**Study materials:** Lecture material, Domenico & Schwartz: Physical and Chemical Hydrogeology.
**Prerequisites:** Hydrological Processes
**Other information:** Organised every other year (on odd years).

### 488118S Laboratory and Field Measurements in Environmental Engineering

**Timing:** Autumn, Spring, periods 1-6
**Scope:** 5-8 ECTS
**Responsible person:** Anna-Kaisa Ronkanen (contact person)
**Objective**: To familiarise the student with laboratory and field measurement techniques in environmental engineering, and to improve student's comprehension to apply techniques and methods in practice.
**Learning outcomes:** The student can determine physical properties of soil, understand the basic of fluid flow and hydraulics in practices and know how to design essential treatment operation in the field of

water treatment. The student also learn to observe and measure phenomena and report on observations in a systematic manner.
**Content**: Physical properties of soil, basic phenomena in hydraulics (pipe flow, water discharge from a tank, open channel flow), essential operation in water treatment (sizing of aerator, control of pH, settling processes, Jar-test), transport processes of harmful substances. Quality and safety of field measurements in environmental engineering. Planning of sampling and handling the results with statistical methods. Soil and water sampling with different sampling methods. Follow-up measurements.
**Working and assessment methods**: Laboratory and field exercises. Report results from laboratory and field exercises.
**Study materials:** Announced during the course.
**Other information:** Other name "Laboratory Exercises and Field Measurements in Environmental Engineering"

### 488110S Water and Wastewater Treatment

**Timing:** Autumn, period 1-2
**Scope:** 7.5 ECTS
**Responsible person:** Laboratory manager Jarmo Sallanko
**Objective:** To familiarize the student with the unit operations of water and wastewater treatment used in communities and industry.
**Contents:** Biological, chemical and mechanical treatment methods, design practise and control of water and wastewater treatment. Handling, utilization and final displacement of waste water sludge. Wastewater treatment of communities and industry. On-site treatment systems.
**Working and assessment methods:** Lectures. Visits to treatment plants. Design exercises and laboratory modelling exercises.
**Study materials:** RIL 123-1.2003: Vesihuolto 1 and RIL 124-2.2004: Vesihuolto (some parts). Material represented in lectures.
**Additional literature:** AWWA, ASCE: Water Treatment Plant Design, McGraw-Hill, London 1998; Metcalf & Eddy: Wastewater Engineering, Treatment and Reuse. 4th ed. McGraw-Hill, London 2003; AWWA (Letterman, R.D. ed.): Water Quality and Treatment, McGraw-Hill, London 1999.
**Prerequisites:** Introduction to Environmental Engineering or equivalent information about water management.

### 488113S Hydraulics for Environmental Engineering

**Timing:** Autumn, periods 2-3
**Scope:** 5 ECTS
**Responsible person:** University lecturer Anna-Kaisa Ronkanen
**Objective:** To assess the fate of detrimental elements in rivers and lakes and using mathematical modelling.
**Learning outcomes:** Students can understand transport processes of harmfull substances in surface waters and they know general modelling and calculations methods in the field.
**Content**: Introduction to modelling in water resources planning, environmental hydraulics, open channel flow, lake hydraulics, processes and water quality, dimensional analysis, hydraulic experiments, transport of conservative and reactive solutes in rivers. Modeling with ordinary differential equations, fully mixed systems, analytical and numerical methods for surface water modeling. Parameter estimation and uncertainty. Tracer tests and measurements systems.
**Working and assessment methods:** Lectures, exercises, and modelling with Matlab. Report about exercises (grade 1-5), examination (accepted/not accepted).
**Study materials**: Surface Water Quality Modelling (Chapra S, 1996, ISBN 0-0701-1-364-5). Fluvial Hydraulics: Flow and Transport Processes in Channels of Simple Geometry. (Walter HG, 1998, ISBN 0-0471-97714-4). Environmental Hydraulics of Open Channel Flows (Chanson H, 2004, ISBN 0-7506-6165-8). Handout and other materials delivered in lectures.
**Prerequisites:** Hydrological Processes and basic university level knowledge of mathematics and physics.
**Other information:** Organised every other year (on even years).

**488115S Advanced Geoenvironmental Engineering**

**Timing:** Autumn, period 2-3
**Scope:** 5 ECTS
**Responsible person:** Kauko Kujala
**Objective:** To familiarize the student with properties of soil, geo-materials and by-products from industry, load, design and construction of geo- and environmental structures.
**Contents:** Soils, geo-materials and by-products. Strength and deformation properties. Calculation of stability, Bearing and soil pressure. Seepage water flow. Soil strengthening, congealing and melting. Soil investigation.
**Working and assessment methods:** Lectures. Calculation and design exercises.
**Study materials:** Course handout and material given during course.

**488117S Water Resources Management**

**Timing:** Autumn, periods 2-3
**Scope:** 7.5 ECTS
**Responsible person:** Prof. Björn Klöve
**Objective:** To familiarise the student with surface waters processes, resources and their management methods.
**Learning outcomes**: To understand different processes, principles and mathematical methods used to manage water resources.
**Contents**: Surface water quality, introduction to biogeochemical processes in lakes and rivers, stream hydraulics and sediment transport, habitat hydraulics, land drainage and environmental impacts, hydro-power and regulation, flood protection, river and lake restoration, IWRM, routing methods, process based hydrological and hydraulic modelling methods, statistical hydrology and uncertainty.
**Working and assessment methods**: Lectures, exercises, modelling, homework.
**Study materials:** Material will be announced later.
**Prerequisites:** Basic knowledge of hydrology and Matlab. Basics of hydrobiology (recommended).
**Other information:** Organised every other year (on odd years)

**488202S Production and Use of Energy**

**Timing:** Autumn, period 1
**Scope:** 3 ECTS
**Responsible person:** University researcher; prof. Riitta Keiski, etc.
**Objective:** To provide the student with the basics of energy supply, use and equipment in Finnish communities and industrial plants. The student will know energy production, transfer, consumption and market structure in Finland. He/she will also know the distribution, adequacy and environmental issues of energy resources
**Learning outcomes**: The student is able to explain different methods and techniques to generate electricity and heat. He/she is able to explain steam power plant operating principles and is able to compare operation of different kinds of steam power plants. The student is able to explain the environmental impacts of energy production and is able compare the environmental impacts of different ways of producing energy. He/she is able to explain how the electricity markets work. The student is also able to explain the adequacy of energy reserves.
**Contents:** Structure of energy production and consumption. Systems for electric transportation, storing and distribution. Distribution and adequacy of energy resources. Effects of environment contracts to the use of energy resources Environmental comparison of different energy production methods and fuels. Energy markets. Development views of energy technology.
**Working and assessment methods:** Lectures
**Study materials:** Lecture handout.

**488203S Industrial Ecology**

**Timing:** Autumn, period 2
**Scope:** 5 ECTS
**Responsible teacher:** University researcher; prof. Riitta Keiski, docent Eva Pongrácz
**Objective:** To familiarize the student with the major concepts of industrial ecology and clarify the role of technology towards sustainable development.

**Learning outcomes:** The student will be able to use the tools of industrial ecology and apply them to industrial activity. The student can also analyze the interaction of industrial, natural and socio-economic systems and able to judiciously suggest changes to industrial practice in order to prevent negative impacts. The student can also analyze the examples of industrial symbioses and eco-industrial parks and able to specify the criteria of success for building eco-industrial parks.
**Contents:** Material and energy flows in economic systems and their environmental impacts. Physical, biological and societal framework of industrial ecology. Industrial metabolism, corporate industrial ecology, eco-efficiency, dematerialization, decarbonisation. Tools of industrial ecology, such as life-cycle assessment, design for the environment, green chemistry and engineering. Systems-level industrial ecology, industrial symbioses, eco-industrial parks.
**Working and assessment methods:** Lectures. Exercise work. Examination.
**Study materials:** Lecture notes; Graedel T.E & Allenby B.R.: Industrial Ecology. New Jersey: Prentice Hall, 2003.

### 488204S Air Pollution Control Engineering

**Timing:** Autumn, period 3
**Scope:** 5 ECTS
**Responsible teacher:** University researcher; prof. Riitta Keiski
**Objective:** To familiarize the student with the effects of air pollution, industrial emissions to air and the control. Legislation of air pollution.
**Learning outcomes:** The student is able to explain what kind of air emissions there are in industry and power plants, and knows their environmental impacts. The student knows the common air pollution control systems for different emissions ($SO_2$, $NO_X$, VOC, $CO_2$, dust) and is able to dimension air pollution cleaning devices. He/she knows how the air emissions are measured. The student knows the main laws related to air emission control.
**Contents:** Effects of pollution to the atmosphere. Acid rain. Climate change. Ozone. Effects of pollution to health and buildings. Legislation. Measurement of pollution. Long range transport and diffusion models. Control of emissions, VOC emissions, $SO_x$ emissions, $NO_x$ emissions, heavy metals, dioxins, freons.
**Working and assessment methods:** Lectures and exercises
**Study materials:** Lecture handout; de Nevers N.: Air Pollution Control Engineering. 2nd ed. McCraw-Hill 2000.
**Additional literature**: Singh H.B.: Composition, Chemistry, and Climate of the Atmosphere. New York 1995; Bretschneider B. & Kurfurst J.: Air Pollution Control Technology. Elsevier, Amsterdam 1987; Hester R.E. & Harrison R.M.: Volatile Organic Compound in the Atmosphere. Issues in Environmental Science and Technology. Vol. 4. Bath 1995; Hester R.E. & Harrison R.M.: Waste Incineration and the Environment. Issues in Environmental Science and Technology. Vol 4. Bath 1995.
**Prerequisites:** The courses Introduction to Process Engineering, Introduction to Environmental Engineering and General and Inorganic Chemistry or respective knowledge recommended beforehand.

### 488205S Environmental Load of Process Industry

**Timing:** Spring, period 6
**Scope:** 4 ECTS
**Responsible person:** Mika Huuhtanen; university researcher
**Objective:** To familiarize the student in more detail with the environmental impacts in process industry such as air pollution, waste water and solid waste. The student will also know about environmental leadership in an industrial plant.
**Learning outcomes**: The student is able to identify the essential features of the environmental load in wood processing, chemical and metallurgical industry. He/she is able to explain the type, quality, quantity and source of emissions. The student is able to apply the main emission control systems and techniques in different industrial sectors. He/she has the skills to apply BAT-techniques in emission control. The student is able to explain the environmental management system of an industrial plant and is able to apply it to an industrial plant.
**Contents:** Effluents: types, quality, quantity, sources. Unit operations in managing effluents, comprehensive effluent treatment. Environmental management systems, environmental licences, environmental reporting and BAT.
**Working and assessment methods:** Lectures
**Study materials:** Material represented in lectures.

**Prerequisites:** The courses Introduction to Process Engineering, Introduction to Environmental Engineering, Air Pollution Control Engineering and Water and Wastewater Treatment recommended beforehand.

### 477503S Simulation

**Timing:** Spring, period 3
**Scope:** 3 ECTS
**Responsible person:** Esko Juuso
**Objectives**: To provide advanced understanding on the methodologies and applications of simulation.
**Learning outcomes**: After the course the student is capable of explaining the concepts and operation principles of process simulators. The student has skills to construct simulation models in Matlab-Simulink environment and to explain the operation of these models. The student recognizes the key problems of the simulation and is able to choose suitable modelling solutions in process modelling and control. Moreover, the student is able to use key concepts of event based, interactive and distributed simulation. After the course the student is able to search other relevant simulation languages and programming tools.
**Contents**: Modelling, modular and equation based simulation, dynamic simulation, intelligent methods in simulation, simulation in automation, event handling in continuous simulation, simulation of production processes, distributed simulation, integration with other systems, simulation languages and programming tools.
**Working and assessment methods**: The course consists of lectures, several exercises, a case study, two seminars and a final report. The case study covers several topics applied in a chosen problem. Each seminar presentation concentrates on a single topic. The final grade is based on the combined points from exercises, case study, seminar and the final report. Final exam is an alternative for the final report. Reports and exams can be done also in English.
**Study materials**: Lecture notes and exercise materials. Material is in Finnish and in English.

### 488002S Advanced Practical Training

**Timing:** Summer (recommended)
**Scope:** 3 ECTS
**Responsible person:** Student counsellor
**Objectives**: To give a deeper and more detailed conception of the areas where the student will possibly work after graduation. Suitable tasks would be supervision tasks and R&D tasks. Students will search the jobs themselves.
**Learning outcomes**: During the advanced practical training the student is exposed to his/her working environment from the point of view of his/her studies and becomes acquainted with another possible future job or with a different assignment already in a familiar working environment. The student can identify the problems associated with the working environment and can solve them. The student can apply theoretical knowledge in practical tasks. The student identifies the tasks appropriate for the Master of Science in Technology at his/her workplace.
**Contents**: Suitable areas for practical training are, for example, regional environment centers, environmental engineering and consulting offices, water-works, biotechnological and food industry, chemical industry, pulp and paper industry, metallurgical and mining industry, partly electronics and automation industry, and other areas in the private and public sectors.

### 6.1.2 Courses from other Departments and/or Faculties at University of Oulu

**555321S Risk Management**

**Timing:** Autumn, periods 1-3
**Scope:** 3 ECTS
**Responsible person:** Professor Pekka Kess (Faculty of Technology, Department of Industrial Engineering and Management)
**Objective:** To familiarize the student to the comprehensive risk management in the enterprises.
**Contents:** Theoretical definition of risk. Risks of business activities and their classification. Methods of risk management. Tools of risk management in the enterprises.
**Working and assessment methods:** Lectures. Case studies in small groups, which will be reported in the closing seminar.
**Study materials:** Bernstein P.L.: Against the Gods - The Remarkable Story of Risk. JohnWiley & Sons Inc., 1996.; Lecture material.

**721236A Principles of Environmental Economics**

**Timing:** Autumn, periods 4-5
**Scope:** 5 ECTS
**Responsible person:** Erkki Mäntymaa (Faculty of Economics and Business Administration)
**Objective:** Students know and are able to verbally and graphically present the most crucial principles and themes of environmental and resource economics.
**Contents:** Optimal harvesting models of renewable and non-renewable natural resources, contradiction between economic growth and resource scarcity, policy instruments for controlling pollution abatement, and valuation methodology concerning non-market resources and environmental amenities.
**Working and assessment methods:** The course can be passed with a literature examination in English. The students wishing to do that should contact the teacher (*).
**Study materials:** Tietenberg, T: Environmental Economics and Policy, 4th ed., 2004. Paavola, J.: Ympäristötalouden perusteet, 1996.
**Language of instruction:** English*

**721704A Business logistics**

**Timing**: Autumn, periods 2-3
**Scope**: 5 ECTS
**Responsible person**: Professor of logistics (Faculty of Economics and Business Administration)
**Objectives**: The student understands how logistics contributes to business competitiveness and knows the central planning principles of logistics activities and their mutual relationships.
**Contents**: Course topics include logistics trade-offs, logistics service level, transport and inventory management, logistics performance measurement, basic production planning and order scheduling, just-in-time logistics, and green logistics. The development of the logistics discipline and current logistics issues will also be discussed.
**Working and assessment methods**: Lectures (30 h), including basic calculations and exercises in classes; Exam (course book, lectures, basic calculation problems). Grading: 1–5.
**Study materials**: Jonsson, P. (2008), Logistics and Supply Chain Management, McGraw-Hill, and supplementary study material in OPTIMA.

## 6.2 COURSES BY OR IN THE NARVIK UNIVERSITY COLLEGE, NORWAY

### 488410A Introduction to Sustainable Energy

**Timing:** Spring, period 5, at the University of Oulu
**Scope:** 10 ECTS
**Location:** University of Oulu, Finland
**Responsible person:** Prof. Bjørn R. Sørensen, Narvik University College
**Objective:** To give an introduction to the most common sustainable energy sources, production forms and distribution methods, and discuss the environmental opportunities, benefits and consequences of utilizing such energy.
**Learning outcomes:** The student will understand the basic physical principles of operation, capacity, growth rates and limitations of the main sources of renewable energy. They will also understand basic energy market operations and how infrastructure and political decisions affect the marketplace.
**Contents:** This subject contains five parts. Each of these modules is described in detail below.
**Working and assessment methods:** Lectures and compulsory exercise done in small groups. Project work. Examination.
**Study materials:** Godfrey Boyle: Renewable Energy, 2nd Edition, Oxford University Press in association with the Open University. John Pitchel: Waste Management Practices. Municipal, hazardous and Industrial. Taylor and Francis Informa.
**Additional literature:** Kanti L. Shah: Basics of Solid and Hazardous Waste Management technology. Prentice Hll. International Energy Agency: Energy Sector Methane Recovery and Use. The Importance of Policy.

#### Part 1: Introduction

**Timing:** Spring, period
**Scope:** 3 ECTS
**Responsible persons:** Prof. Bjørn Reidar Sørensen and assistant prof. Elisabeth Román
**Contents:**

a) The science of energy
b) Sources of energy
c) The importance of renewable energy for the development of society
d) Renewable energy flows (forms, quality, planetary energy balance
e) The threat of the green house effect and global climate change
f) The Kyoto Convention
g) Global energy policies
h) National and EU legislation
i) Competing environment friendly energy forms
j) Environmental impact assessment
k) Energy distribution forms
l) LCC/LCP analysis
m) Strategic planning for sustainable energy

#### Part 2: Renewable Energy sources

**Timing:** Spring, period
**Scope:** 2 ECTS
**Responsible persons:** Mattew Homola and Steinar Svarte
**Contents:**

a) Solar (thermal collectors - water heating, photovoltaic, solar thermal electric, other solar)
b) Hydro
c) Wind
d) Biomass and bio fuels
e) Wave
f) Tidal
g) Geothermal
h) Hydrogen

**Part 3: Storage and transmission**

**Timing:** Spring, period
**Scope:** 1
**Responsible persons:** Mattew Homola and Steinar Svarte
**Contents:**

a) Chemical
b) Heat
c) Electrical
d) Mechanical

**Part 4: Market and infrastructure**

**Timing:** Spring, period
**Scope:** 2 ECTS
**Responsible persons:** Mattew Homola and Steinar Svarte
**Contents:**

a) Nordic cooperation
b) The Nordic electric power system
c) The electrical characteristics of the Nordic electric power system
d) Transmission system operators
e) Nord Pool, the Nordic electricity exchange
f) The Nordic electricity market
g) Elspot
h) Elbas
i) The regulating power market
j) Biomass markets
k) $CO_2$ - quotas trading
l) Thermal energy distribution
m) District heating systems

**Part 5: Energy and use**

**Timing:** Spring, period
**Scope:** 2 ECTS
**Responsible persons: Bjørn Reidar Sørensen**
**Contents:**

a) Buildings and industry
b) Transport
c) Energy efficiency
d) Energy management

**488420S Solar and Wind Energy**

**Timing:** Autumn semester, in the Narvik University College
**Scope:** 10 ECTS
**Location:** Narvik University College, Norway
**Responsible person:** Ass. Prof. Svein Arne Munkvold. Instructors (lecturers): Svein A. Munkvold, Matthew Homola
**Objective:** A basic introduction to qualities and quantities of sustainable wind and solar power. Physical principles of wind and solar energy conversion to useable energy and theoretical limits to efficiency and resource base. Understand how the wind and solar power production characteristics match with the load characteristics and integrate into an electrical power grid.
**Learning outcomes:** The successful student will understand the physical principles for wind and solar energy understand important design criteria for wind and solar energy converters and be able to calculate efficiencies of the two technologies. They will also understand how to evaluate the available resource at a site and be able to calculate an expected production from a site.
**Contents:** 1) Electrical theory: Networks and Kirchhoffs laws. Capacitors and inductors. Maximum power transfer. The pn-junction. 2) Wind energy: Energy in the wind. Characteristics of wind. Methods of conversion. Limits of conversion efficiency. Wind power conversion and control systems. Design options. Excursion to Nygårdsfjell. Estimating energy resource. Value of wind energy. Integration in electrical

systems.Wind generation environmental impacts. 3) Solar energy: Solar physics. Semiconductor materials. The pn-junction and doping. Photovoltaics. Efficiency and fill-factor. The influence of heating and radiation. Power distribution and regulation. PV technologies. Wafer production. Excursion to ScanCell.
**Working and assessment methods:** Lectures and compulsory exercise done in small groups. Project work. Examination.
**Study materials:** Renewable Energy Resources – Second edition, J. Twidell and T. Weir, Taylor and Francis, 2006
**Additional literature:** Wind Energy Explained, J.F. Manwell, J.G. McGowan and A.L. Rogers, 2002. Handbook of photovoltaic, Science and Engineering, Wiley 2003.
**Prerequisites:** Course Introduction to Sustainable Energy.

### 488421S Bio-Energy

**Timing:** Autumn semester, in the Narvik University College
**Scope:** 5 ECTS
**Location:** Narvik University College, Norway
**Responsible person:** Assistant prof. Elisabeth Román
**Objective:** To introduce how different sources of biomass can be transferred and utilized as bio-fuels.
**Learning outcomes:** The successful student will have an overview of the different bio energy sources and how they can be used in order to produce energy. The student will also know about actual strategic documents in order to utilize bio-energy. The student will be aware of negative impacts of pollution from incineration of waste.
**Contents:** Biomass - Earths living matter. Bio-energy sources: Woody crops, wastes, landfill gas, charcoal, pelleted fuel. Production of gaseous fuel from biomass, anaerobic digestion from municipal solid waste (MSW), gasification. Production of liquid fuels from biomass – pyrolysis. Fermentation to produce alcohols. Vegetables oils to biodiesel.
Environmental benefits and impacts: Emissions, Land use. Actual legislation and agreements concerning use of sustainable energy. International Energy Agency. The EU-waste directive Energy balance, Electricity from wastes and from Energy crops. Future aspects.
**Working and assessment methods:** Lectures and compulsory exercise done in small groups. Project work. Examination.
**Study materials:** Godfrey Boyle: Renewable Energy, 2nd Edition, Oxford University Press in association with the Open University. John Pitchel: Waste Management Practices. Municipal, hazardous and industrial. Taylor and Francis Informa.
**Additional literature:** Kanti L. Shah: Basics of Solid and Hazardous Waste Management technology. Prentice Hll. International Energy Agency: Energy Sector Methane Recovery and Use. The importance of Policy.
**Prerequisites:** Course Introduction to Sustainable Energy.

### 488422S Energy Systems in Buildings and Industry

**Timing:** Autumn semester
**Scope:** 5 ECTS
**Location:** Narvik University College, Norway
**Responsible person:** Prof. Bjørn R. Sørensen. Instructors (supervisors): Prof. Bjørn R. Sørensen, Raymond Riise.
**Objective:** Give the student broad competence on and understanding of how to achieve improved energy efficiency in buildings and industry in the northern areas.
**Learning outcomes:** The students will achieve good skills and expertise on consumer energy systems to assess and solve real world problems in buildings and industry. The students will gain broad understanding of the importance of energy efficiency. The students will be able to assess and design energy efficient solutions for buildings and industries, and the appurtenant installations. This includes mapping and investigation of the prevailing standard of a building, calculation of the impact from different measures, projecting and implementation of measures, and post evaluation of the gained savings.
**Contents:** 1) Introduction: The role of energy efficiency in a global perspective. Introduction to energy efficiency. The potential of energy reduction. Indoor climate and energy saving. Energy efficiency and environment. Global (?) 2) Energy end use in buildings: Climatic factors. Cold climate challenges. How to meet indoor climate requirements and reduce energy usage. Energy supply to and distribution in buildings. District heating systems. Energy stations in buildings. Energy flexibility. Free energy. Regulations and

standards. 3) The building envelope: Thermal insulation of external walls, roofs and floors. Heat transfer through windows and glazed areas. The impact from cold bridges. Infiltration and exfiltration. Solar radiation on surfaces and internal heat sources. Dynamic conditions, thermal inertia, time constants. Calculation methods for design power and energy consumption. 4) Technical installations in buildings and industry: Ventilation systems and components. Heating systems and components. Cooling systems and components. Lights and electrical equipment. Automation and control strategies. Operation and maintenance procedures. 5) Economical and environmental evaluation: Calculation methods. CO2 equivalents.
**Working and assessment methods:** Lectures, exercises and problem solving. Laboratory exercise. Students will be evaluated based on a final exam.
**Study materials:** Compendia (in English), notes, lecture notes and exercises
**Prerequisites:** Course Introduction to Sustainable Energy.

**488423S Project Work (Pre-master Work) – Sustainable energy**

**Timing:** Autumn semester
**Scope:** 10 ECTS
**Location:** Narvik University College, Norway
**Responsible person:** Prof. Bjørn R. Sørensen. Instructors (supervisors): Bjørn R. Sørensen, Raymond Riise, Elisabeth Roman, Matthew Homola, Svein Arne Munkvold, Trond Østrem, Svein Ove Hareide.
**Objective:** Give the student experience of solving real world scientific problems related to sustainable energy in cold climate areas. Independent problem solving is essential in this course.
**Learning outcomes:** The specific learning outcome depends on the subject chosen for the project work. The student will have a chance to choose the field that has most interest. The general outcome is that the student will learn how to carry through a real world project and gain experience of scientific work within the energy field. The student will gain insight to the relevant initiatives, instruments and measures required for sustainable energy production, distribution and/or end use.
**Contents:** 1) Project development: Define the project frames and main goals. Describe the scientific work. Form a project description. Describe methods and resources. Describe the activities. Plan for propulsion and budget. Literature reviews. 2) Collect and review the state-of-the-art literature on the relevant subjects: Summarize the findings from literature. Adjust the angle of further work. 3) Carry out investigations and/or experiments 4) Analysis and discussion of the problems 5) Thesis / report / presentation.
**Working and assessment methods:** Personal supervision of each student. Students will be evaluated based on a final report and presentation.
**Study materials:** Varies, dependent on chosen subject
**Prerequisites:** Preceding courses in the study programme must have be completed.

**Diploma Thesis on Sustainable Energy at NUC**

**Timing:** Spring Narvik University College
**Scope:** 30 ECTS
**Location:** Narvik University College, Norway
**Responsible person:** Prof. Bjørn R. Sørensen
**Instructors (supervisors):** Bjørn R. Sørensen, Raymond Riise, Elisabeth Roman, Matthew Homola, Svein Arne Munkvold, Trond Østrem, Svein Ove Hareide.
**Objective:** The Diploma thesis will give the successful student relevant professional experience of solving real world scientific problems related to sustainable energy in cold climate areas.
**Learning outcomes:** The specific learning outcome depends on the subject chosen for the project work. The student will have an opportunity to choose an area that has most interest. The general outcome is that the student will learn how to carry through a real world project and gain experience of scientific work within the energy field. The Diploma thesis is regarded as an independent work, and demands the candidates to assess and analyze problems, and to discuss and select solutions best suited to solve the problems. Besides giving knowledge of analytical analysis of problems, the Diploma thesis also gives the candidates insight into R&D areas and research methods. The Diploma thesis will better enable the candidate to plan, pursue and follow-up projects.
**Contents:** The content of the Diploma thesis strongly depends on the chosen subject. The following thus gives the outline or general principles of any Diploma thesis. The Diploma thesis shall contain elements of scientific work. 1) Project development and definition: Define the project frames and main goals. Describe the scientific work. Form a project description and –plan. Describe scientific methods and resources.

Describe the activities. Plan for propulsion and budget. 2) Literature reviews: Collect and review the state-of-the-art literature on the relevant subjects. Summarize the findings from literature. Adjust the angle of further work. 3) Carry out investigations and/or experiments 4) Analysis and discussion of the problems 5) Develop solutions 6) Final diploma thesis delivery 7) Presentation and self evaluation.
**Working and assessment methods:** Personal supervision of each student. Students will be evaluated based on a final report and presentation.
**Study materials:** Varies, dependent on chosen subject
**Prerequisites:** Preceding courses in the study programme must be completed.